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Comparative toxicity of four pyrethroid insecticides against red palm weevil, *Rhynchophorus ferrugineus* (Olivier) under laboratory conditions

By

M. M. Abo-El-Saad, A.M. Ajlan, M.S. Shawir, K.S. Abdulsalam and M. A. Rezk

Plant Protection Dept., College of Agricultural and Food Sciences, King Faisal University.

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ABSTRACT

Field strain of different stages of *Rhynchophorus ferrugineus* were collected from Al-Hassa, in Eastern Province, Saudi Arabia. Four different pyrethroid insecticides were evaluated against larval and adult (male & female) stages of *R. ferrugineus* (Olivier) under laboratory conditions. All stages were exposed to the treated sugarcane pieces in different concentrations of the following synthetic pyrethroids; permethrin (Type I), cypermethrin, deltamethrin and fenvalerate (Type II). Percent mortality of each stage was recorded after 24 and 48 hr of insecticide exposure. The data showed that cypermethrin was more potent after 24 hr when compared to the other insecticides against males and females in the order of cypermethrin > permethrin > deltamethrin > fenvalerate. By increasing exposure time for the insecticides up to 48 hr, permethrin exhibited knockdown effect on both male and female adults, since the LC_{50} value was increased from 52.4 ppm at 24 hr to 175.3 at 48 hr for males and from 85.1 ppm to 147.7 ppm for females. In conclusion, values of LC_{50} revealed that cypermethrin were the most effective synthetic pyrethroid on male and female adults

after 24 hr when compared to the other compounds. Moreover, the results were discussed in view of structure-activity relationship of these compounds and their insecticidal activity against red palm weevil.

INTRODUCTION

Red palm weevil, *Rhynchophorus ferrugineus* (Olivier), invaded Qatif in Estern region of Saudi Arabia in the mid-1980's. The weevil has expanded its range very rapidly (Gush, 1997; Abraham *et al.*, 1998 and Ajlan *et al.*, 2000). It causes severe damage to date palms and threat the date palm which affect the dates industry. The control management of red palm weevil was found to be very difficult due to living nature of the larvae, effective methods and critical time to discover the beginning of infestation. Current tactics employed to manage the weevil are largely based on insecticide applications. Insecticides are applied as preventive and curative to limit the spread of weevils (Abuzuhairah *et al.*, 1996). The recent researches have focused on integrated pest management (IPM) involving surveillance, pheromone lures, cultural control and chemical treatments for the management of *R. ferrugineus* (Abraham *et al.*, 1998). Other techniques such as sanitation, baited traps of red palm weevils have been applied in infested areas and where proved by using in combination with chemical pesticides in field (Abraham *et al.*, 1989; Moural *et al.*, 1995). The choice of the chemical pesticides regularly being used in the field after laboratory test on promising compounds. For example, Abraham *et al.* (1975) evaluated seven insecticides for controling of red palm weevil. They reported that dichlorvos at 0.25%, methyl-O-demeton, phosphamidon and arprocarb at 0.5%, trichlorphon and malathion at 1.0% and parathion at 2.0% gave 100% mortality on the seventh day. Abraham and Vidyasagar (1992), reported that insecticides such as chlorpyrifos, endosulfan and methiothion at 0.1% are recommended for red palm weevil control. In addition, Cabello *et al.* (1997), concluded that imidacloprid (Confidor) may be used to control all instars of *R. ferrugineus* larvae. Furthermore, Ajlan *et al.* (2000) suggested that a mixture of pirimiphos-methyl and either oxydemeton-methyl or trichlorphon is suitable to control the larval and adult stages of *R. ferrugineus*.

The aim of the present work is to evaluate certain synthetic insecticides against *R. ferrugineus* stages as an attempt to find out a promising insecticide to be used in the field as one angle of integrated pest management.

MATERIALS AND METHODS

Insect: Different stages of *R. ferrugineus* were collected from the highly infested palm trees in AL-Hassa Eastern Province fields of Saudi Arabia.

Chemicals: Sumicidin (fenvalerate) 20% EC {(RS)- α-cyano-3-phenoxybenzyl (RS) –2 - (4-chlorophenyl) - 3-methylbutyrate}; Ambush (permethrin)10%EC {3-phenoxybenzyl (1RS)-cis,trans-3-(2,2-dichlorovinyl)-2,2-dimethylcyclo- propane-carboxylate}; Decis (deltamethrin) 10% EC {(S)- α-cyano-3-phenoxybenzyl (1R,3R)- 3- (2,2-dibromovinyl) - 2, 2 - dimethyl-cyclopropane-carboxylate}; Alpha-cide (cypermethrin) 50 EC } (±)α-cyano-3-phenoxybenzyl (±)- cis,trans-3- (2,2-dichlorovinyl) -2,2-dimethylcyclo-propanecarboxylate}. All the insecticides were purchased locally from Alwaha Co. and used for the susceptibility test.

Susceptibility test: Laboratory trials against adults (male & female) and larval instars of R. *ferrugineus* were conducted in glass jars (500 cc) to determine the toxicity parameters according to Ajlan et al. 2000. Small pieces of sugarcane stem with equal sizes (5cm long X 0.75 cm in diameters) were soaked for 1 min in different dilution of the insecticides. Five larvae ~ 4-5 weeks old (5 cm long) and/or adults (male & female) were exposed to the treated sugarcane pieces in the glass jars, covered with perforated plastic cap. Similar pieces of sugarcane stem were soaked in distilled water and served as control. In order to assess the effect of insecticides, the insects were examined after 24 and 48 hours from exposure and the percentages of mortality were recorded. An insect was considered dead if it neither moved nor responded by reflex movement, when touched. Every insecticide concentration was replicated three times. Normal Equivalent Deviates; Chi Squares; 50% and 95% lethal concentrations, and their Fiducial limits, were calculated according to Finney (1971).

RESULTS AND DISCUSSION

Comparative Toxicity: Toxicity of certain synthetic pyrethroid insecticides against different stages of *R. ferrugineus* was determined as shown in Tables (1 and 2) represented by LC_{50} values. The data showed that cypermethrin was more toxic compared to the other tested pyrethroids in the following order; cypermethrin > permethrin > deltamethrin > fenvalerate after 24 hr of insecticide exposure on both insect males and females. However, deltamethrin was more potent than cypermethrin and other compounds against larvae. The LC_{50} values for larvae were 71 ppm and 139.1 ppm for deltamethrin and cypermethrin, respectively, while it was more than 1600 ppm for both permethrin and fenvalerate. The LC_{50} value of deltamethrin for larvae was 24.6 ppm after 48 hr whereas the values for cypermethrin, fenvalerate and permethrin were 31.85, 291.9 and 517.5 ppm, respectively.

On the other hand, the LC_{95} values of the tested insecticides against *R. ferrugineus* are plotted as shown in Fig. (1,2 and 3). The LC_{95} values were observed to depend on the type of insecticide, insect stage, sex and exposure time of insecticide. Thus, tested insecticides against males showed their effect in the following order; cypermethrin> fenvalerate > permethrin > deltamethrin after 24 hr of insecticide exposure, where the LC_{95} values were 177.2, 497.3, 1656 and 3687 ppm, respectively. After 48 hr, the order of insecticide toxicities were cypermethrin > permethrin > deltamethrin > fenvalerate. While after 72 hr , the order was changed by cypermethrin > permethrin = deltamethrin > fenvalerate . Furthermore, the same manner could be observed by effecting of these insecticides against females and larvae. In general, the results clearly showed that cypermethrin was a better synthetic pyrethroids against all stages of *R. ferrugineus*. Suggesting, cypermethrin could be a useful insecticide in implication with tactic strategy of integrated pest management.

In addition, the data revealed a knockdown effect of some of these insecticides against *R. ferrugineus* by increasing exposure time of insect to these insecticides (Tables 1 and 2). In the case of cypermethrin against females, the data showed that LC_{50} after 24 hr was 25.1 ppm and it was increased to 55.19 ppm after 48 hr. These data could be explained by the phenomenon so-called knockdown in which the insect could get recovery by increasing the activity of detoxificating enzymes such as mixted function oxidases and cytochrome P450 monooxygenases (Feyereisen, 1999). However, cypermethrin showed no knockdown effect on larva. Furthermore, permethrin dramatically showed knockdown effect as shown in Tables (1 and 2) against males and females since, the value of LC_{50} increased from 52.4 to 175.3 ppm for adult males and from 85.1 to 147.7 ppm for females.

Table (1): Effect of some pyrethroid insecticides on *R. ferrugineus* after 24 hr of exposure.

Insecticide	Life Stage	LC_{50} (ppm)	Regression of N.E.D (Y) on log dose (X)	P**
Cypermethrin	Male	41.5 (36.1-47.7)*	Y =-4.2 + 2.6x	0.43
	Female	25.1 (2.6-196.7)	Y =-2.5+ 1.8x	0.67
	Larva	139.1 (26.6-460.3)	Y =-3.2 + 1.5x	0.01
Deltamethrin	Male	85.6 (64.0-114.9)	Y =-1.9 + 1.0x	0.23
	Female	192.3 (114.2-263.0)	Y =-3.3 + 1.5x	0.63
	Larva	71.0 (54.8-91.8)	Y =-1.9 + 1.1x	0.01
Fenvalerate	Male	135.8 (118.8-155.2)	Y =-6.2 + 2.9x	0.65
	Female	238.1 (32.7-1953.7)	Y = -1.9 + 0.6x	0.91
	Larva	>1600		--
Permethrin	Male	52.4 (39.1-70.5)	Y =1.9 + 1.1x	0.29
	Female	85.1(70.3-103.2)	Y = -4.4 + 2.3x	0.72
	Larva	>1600		

*95% Fiducial Limits
**Probability

Table (2): Effect of some pyrethroid insecticides on *R. ferrugineus* after 48 hr of exposure.

Insecticide	Life Stage	LC_{50} (ppm)	Regression of N.E.D (Y) on log dose (X)	P**
Cypermethrin	Male	21.7 (3.2-138.5)*	Y =-3.0 + 2.3x	0.10
	Female	55.19 (12.6-240.3)	Y =-5.5 + 3.1x	0.63
	Larva	31.85 (2.7-344.9)	Y =-2.5 + 1.6x	0.58
Deltamethrin	Male	46.9 (33.2-66.5)	Y =-1.3 + 1.0x	0.11
	Female	199.9 (147.8-272.1)	Y =-3.5 + 1.5x	0.63
	Larva	24.6 (17.8-33.7)	Y =-2.0 + 1.5x	0.09
Fenvalerate	Male	54.7 (44.5-67.3)	Y =-2.3 +1.3x	0.15
	Female	125.8 (99.7-158.9)	Y = -3.2 + 1.5x	0.43
	Larva	291.9 (200.2-425.2)	Y = -1.7 + 0.7x	0.09
Permethrin	Male	175.3 (78.5-408.9)	Y =-1.6 + 0.7x	0.01
	Female	147.7(102.6-214.0)	Y = -3.7 + 1.7x	0.77
	Larva	517.5 (440.4-608.3)	Y = -4.8 + 1.8x	0.18

* 95% Fiducial Limits
** Probability

A unique characterestic of pyrethroid insecticides is the process of konckdown, which can be defined as rapid immobilization of insect after exposure to the insecticide and often recover occurred after knockdown. Different structural and physical requirements appear to determine the knockdown and killing potency of pyrethroids (i.e. some compounds are effective knockdown agents and relatively poor toxin while other are ineffective knockdown but highly toxic). Therefore, it has been hypothesized that knockdown results from the excessive stimulatory effect of pyrethroids on sensory nerves and sense organs located close to the surface disruptin the normal information flow towards the central nervous system (Leahey, 1985).

Structure-activity relationship: Table (3) summarized the structure-activity relationship between permethrin, cypermethrin, dletamethrin and fenvalerate against *R. ferrugineus*. The data showed significantlly different susceptibility toward males, females and larvae. Cypermethrin was more toxic against males when compared to the other compounds in the following order; cypermethrin > permethrin > deltamethrin > fenvalerate as expressed by LC_{95} after 48 hr of insecticide exposure. It seems that the major achievement was the enhanced activity accompanying incorporation of a cyano group on the alpha carbon of the 3-phenoxybenzyl alcohol esters as seen in cypermethrin, however, the activity was decreased by replacing cyno group by hydrogen atom in the same position to give permethrin compound. Moreover, by replacing the dichorovinyl group in cypermethrin by dibromovinyl group resulted in deltamethrin, the insecticidal activity was decreased after 48 hr. The presence of a cyclopropane ring next to the ester linkage was not essential for high insecticidal activity as in fenvalerate. Furthermore, the insecticidal activity of such insecticides on female insects was found to have the following order of toxicity;

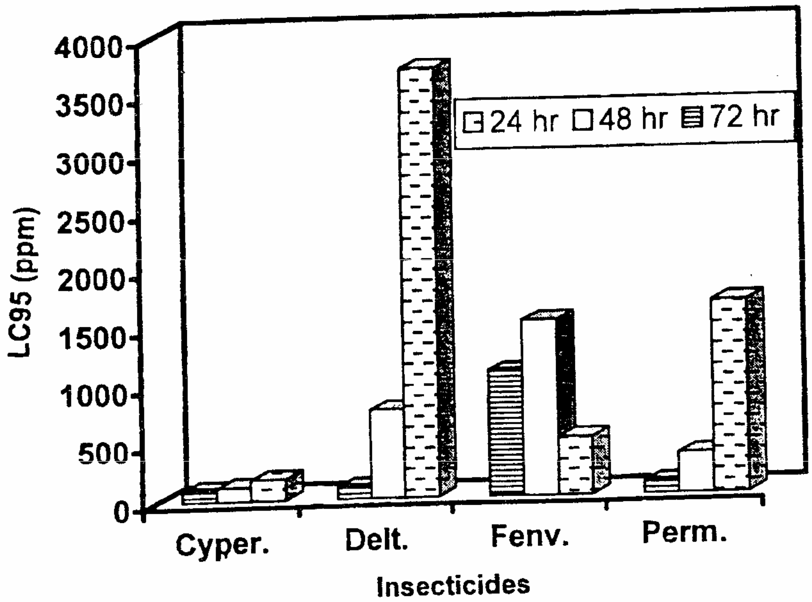


Fig. (1): Lethal concentration to 95% of different synthetic pyrethroids against males of *R. ferrugineus* at different exposure time.

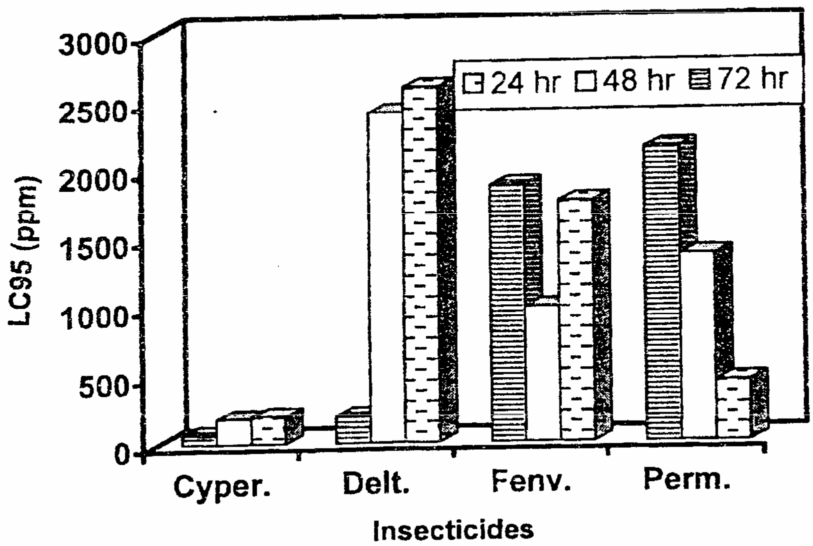


Fig. (2): Lethal concentration to 95% of different synthetic pyrethroids against females of *R. ferrugineus* at different exposure time.

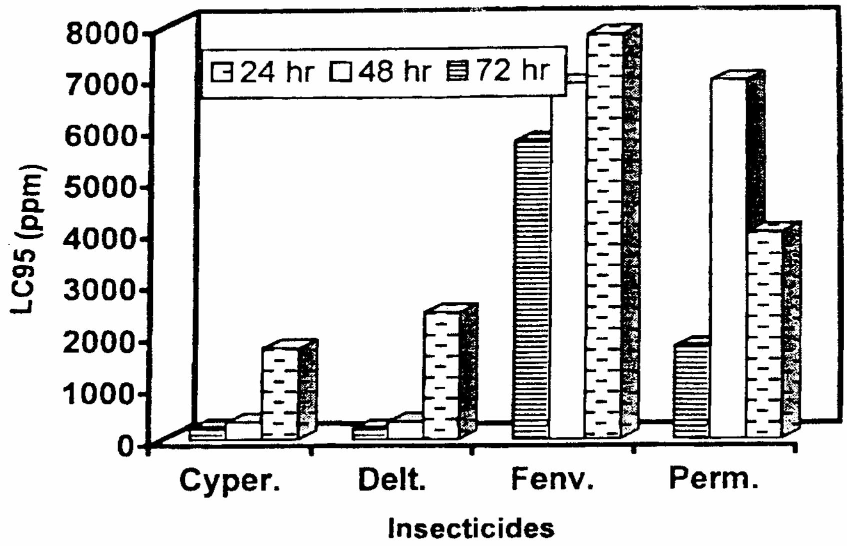
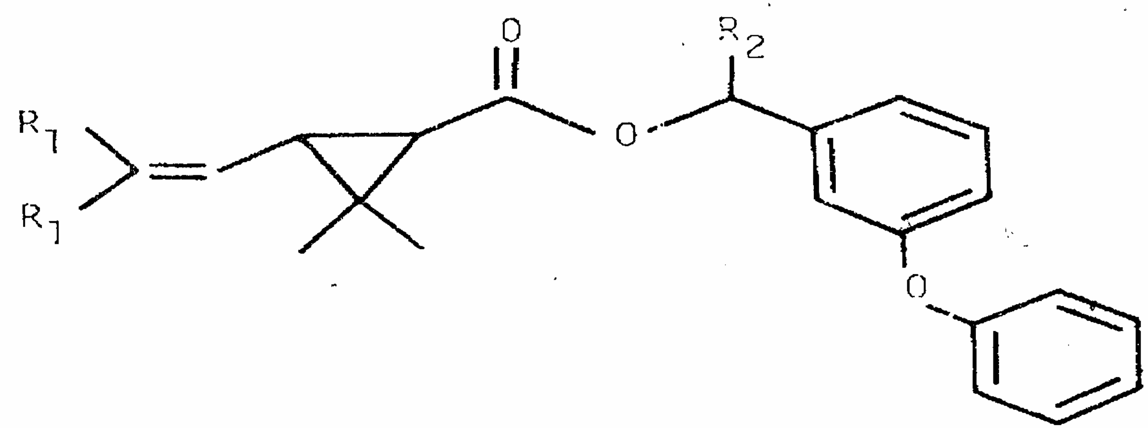


Fig. (3): Lethal concentration to 95% of different synthetic pyrethroids against larvae of *R. ferrugineus* at different exposure time.

cypermethrin > fenvalerate > permethrin > deltamethrin, whereas the insecticidal activity on larvae was cypermethrin > deltamethrin> fenvalerate > permethrin. It could be concluded that cypermethrin was the most effective one against all stages of *R. ferrugineus*.

The synthetic pyrethroids might play an important role in control *R. ferrugineus*. The success of the synthetic pyrethroids which representative the major class of insecticides for crop protection, is due to their high potency and selectivity as nerve poisons. Moreover, all pyrethroids are lipophilic compounds and almost insoluble in water. Because of high lipophilicity, cuticular peneteration in such insect is favored and retention on the cuticle of plant surfaces minimizes systemic movement. Their strong lipophilic character suggests that they would be strongly adsorbed in most soils and not leached readily from the point of application. Therefore, ground and surface water will receive contamination only by direct application and/or by the

Table (3): Structure-activity relationship of certain synthetic pyrethroids against red palm weevil after 48 hr of insecticide exposure.



R_1 =Cl or Br
R_2 = CN

Insecticide	Type	Cyno group	Dichlorvinyl	dibromvinyl	LC_{95} (ppm)		
					Male	Female	Larva
Permethrin	I	-	+	-	343	1361	6918
Cypermethrin	II	+	+	-	116	184	317
Deltamethrin	II	+	-	+	759	2409	323
Fenvalerate	II	+	-	-	1510	985	6855

erosion of treated soil and by diffusion or leaching (Leahey, 1985). For above reasons it may be possible to suggest that pyrethroids are suitable insecticides in control *R. ferrugineus* in palm trees.

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الملخص العربى

مقارنة سمية أربعة مبيدات بيرثرويدية على سوسة النخيل الحمراء تحت الظروف المعملية

محمود أبوالسعد ، عبدالعزيز العجلان ، محمد شعوير ،
خالد عبد السلام ، محمد رزق
قسم وقاية النبات - كلية العلوم الزراعية والأغذية - جامعة الملك فيصل

تم تجميع الأطوار المختلفة لحشرة سوسة النخيل الحمراء من الأحساء-المنطقة الشرقية بالمملكة العربية السعودية وذلك لدراسة كفاءة بعض مبيدات البيرثرويدات معملياً. حيث تم إختيار أربعة مبيدات من هذه المجموعة هي بيرمثرين ، سيبرمثرين ، دلتاميثرين ، فينفاليريت لدراسة كفاءتها معملياً على كل من يرقات و ذكور و إناث حشرة سوسة النخيل الحمراء وذلك بتعريضها إلى قطع من قصب السكر الذي سبق معاملته بسلسلة من تركيزات هذه المبيدات.

لقد أوضحت النتائج بعد ٢٤ ساعة من التعريض إختلاف في سميتها بالترتيب التالى سيبرميثرين > بيرمثرين > دلتاميثرين > فينفاليريت . كما بينت النتائج أنه بزيادة زمن التعريض لمبيد البيرمثرين إلى ٤٨ ساعة قد اظهر مبيد البيرمثيرين صدمة عصبية (knockdown) للذكور و الإناث حيث ازدادت قيم الـ LC_{50} من ٥٢ جزء في المليون بعد ٢٤ ساعة علي الذكور إلي ١٧٥ جزء فى المليون بعد ٤٨ ساعة ، بينما علي الإناث ازدادت من ٨٥ جزء فى المليون إلي ١٤٧ جزء في المليون بعد ٤٨ ساعة.